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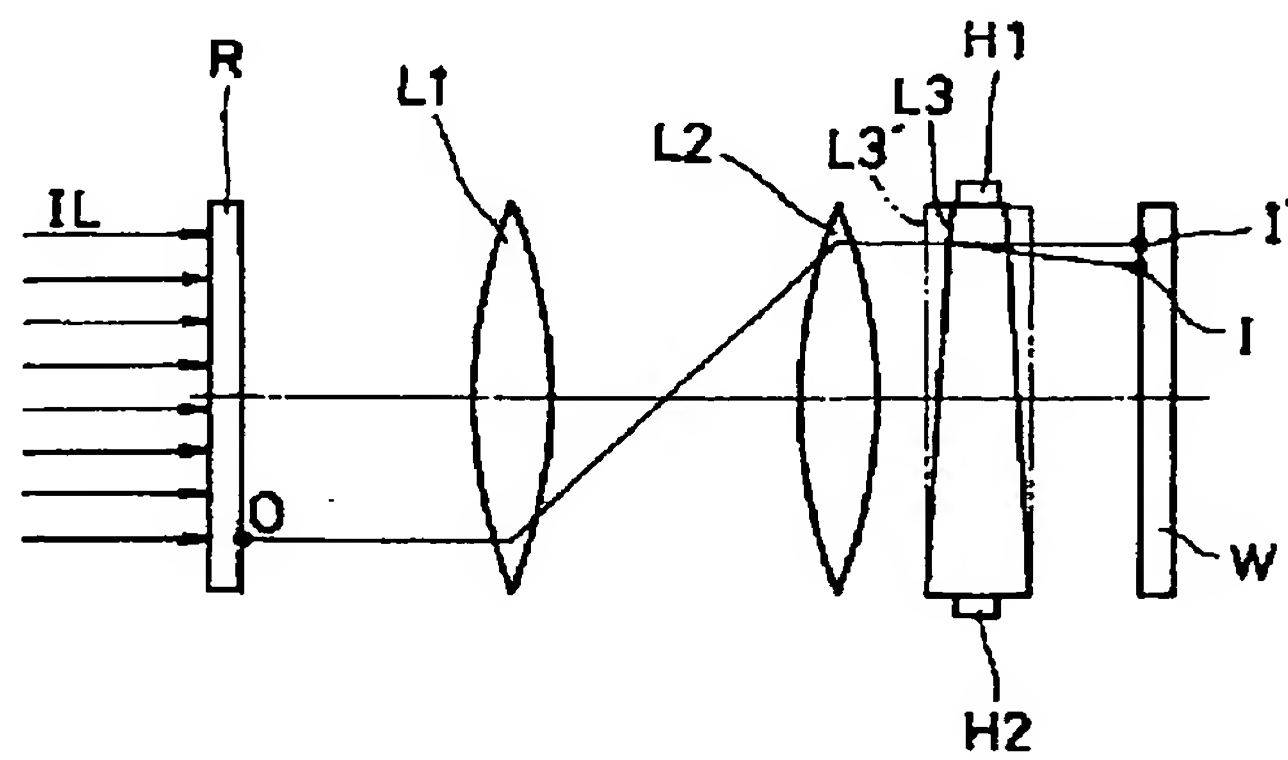
(54)【発明の名称】投影露光装置

(57)【要約】
【課題】　比較的簡単な構成で投影光学系の歪曲収差を補正できるようにする。
【解決手段】　レチクルＲに形成されたパターンをウエハＷ上に投影する投影光学系ＰＬを構成する光学素子Ｌ３にヒーターＨ１，Ｈ２等の温度可変手段を設け、光学素子Ｌ３に所定の温度分布を与えて物理的に変形（Ｌ３’）させることで投影光学系ＰＬの光学特性を修正し、歪曲収差を補正する。



【特許請求の範囲】

【請求項1】　レチクルを照明する照明系と、感光基板を保持する基板ステージと、前記レチクルのパターン像を前記感光基板上に形成する投影光学系とを含む投影露光装置において、
前記投影光学系を構成する光学素子の温度を変化させる温度可変手段と、前記光学素子の温度分布を計測する温度計測手段と、前記温度計測手段によって計測された温度分布に基づいて前記温度可変手段を制御して前記光学素子に所定の温度分布を与えることにより前記投影光学系の収差を補正する温度分布制御手段とを備えることを特徴とする投影露光装置。

【請求項2】　前記温度可変手段として、前記投影光学系を構成する1つ又は複数の光学素子の外周に配設された複数のヒートポンプを備えることを特徴とする請求項1記載の投影露光装置。

【請求項3】　前記温度可変手段として、前記光学素子に所望のパターンで赤外線を照射する赤外線照射手段を備え、前記温度計測手段として放射温度計を備えることを特徴とする請求項1又は2記載の投影露光装置。

【請求項4】　前記光学素子の温度分布と前記投影光学系の光学特性とを対応させて記憶した記憶手段を備えることを特徴とする請求項1記載の投影露光装置。

【請求項5】　前記温度分布制御手段による前記温度可変手段の制御結果としての前記投影光学系の結像特性をシミュレートするシミュレーション手段を備え、前記温度分布制御手段は前記シミュレーション手段によるシミュレーションの結果をもとに前記温度可変手段を制御することを特徴とする請求項1記載の投影露光装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、半導体デバイスや液晶ディスプレイ等の製造に用いられる投影露光装置に関するものである。

【0002】

【従来の技術】半導体素子、液晶ディスプレイ、薄膜磁気ヘッド等を製造するフォトリソグラフ工程では、投影露光装置を用いてフォトマスク又はレチクル（以下、レチクルという）に形成されたパターンをフォトレジスト等の感光剤が塗布されたウエハやガラスプレート等の感光基板上に投影露光することが行われる。このパターン露光は、感光基板上にすでに形成されているパターンの上に重ね合わせて露光することを複数回繰り返して行うのが通常である。感光基板上に形成されたパターンの精度は完成品であるデバイスの性能に直接影響を与えるため、投影露光装置の投影光学系は像の歪み（歪曲収差）を極めて小さいものとすることが要求されている。そのために、投影レンズの設計の際に原理的に生ずる歪曲収差を極めて小さくするのはむろんのこと、製造の際に生ずる光学素子の製造誤差や組立公差を小さくすることが必要とされている。また、気圧や温度などの環境パラメータの変化や、露光時に露光光を吸収することによる光学素子の温度変化などによっても投影光学系の収差が変動するために、これらの変動に対する補正も必要である。

【0003】従来、投影露光装置の製造時に生ずる誤差を抑えるためには次のようなことが行われてきた。一つは、使用する光学素子自体の誤差の低減である。例えば、屈折型の光学素子（いわゆる光学レンズ）を製作する際には、屈折率均一性の高い光学材料を使用し、かつ極めて高い精度で加工を行うことにより光学設計上の理想値に近いものを作り上げようという努力がなされてきた。また、完成された光学部品が変形を生じさせることなく正確な位置関係に保持されるようにマウントに工夫を加えることにより、設計された性能の達成が図られてきた。

【0004】しかしながら、投影露光装置の投影光学系の製造においては、非常に高度の性能が要求されるため、個々の部品に対して要求される製造精度が現在の技術で得られる加工精度の限界を越えてしまうことが起こる。そのため、上述のような方法だけでは必要な性能を得ることができず、最終的に組上がった光学系の各部に対して調整を繰り返すことで、試行錯誤的に投影光学系全体として必要な性能を達成させるという手法を採っているのが実状である。

【0005】また、使用環境などの変化によって生じる収差の変動に対しては、投影光学系全体を環境制御システム内に入れたり、投影光学系を温度制御ジャケットで覆うことにより外部環境の変化から隔離して保護する方法、もしくは投影光学系の一部分を密閉構造にしてその部分の気圧を制御したり、一部の光学素子を動かす方法によって環境変化による収差の変動を補償する構成を採っていた。

【0006】

【発明が解決しようとする課題】上述した従来の投影露光装置には、次のような問題がある。即ち、従来は製造時に生じる誤差に対して最終的に組み立てられた投影光学系について調整を行うことで補償を行っていたが、その調整にも高い精度が必要とされ、また全ての性能について組み上げられた製品上で調整できるわけではない。

【0007】投影光学系の歪曲収差（ディストーション）の補正の場合、回転対称成分の補正には投影光学系を構成する光学素子間の距離を数カ所で調整することにより大部分を修正できるし、いくつかの非回転対称な成分についても光学素子を3次元的に動かすことにより修正が可能である。しかしながら、製品の完成後に全ての成分について修正することは精度やアクセス性などの面から極めて困難であった。

【0008】また、光学素子を形成する光学ガラス材が屈折率分布を持っていた場合や保持部品が変形してしま

った場合など、光学系を構成する部品のレベルまで分解して交換しないと修正が不可能なものも有り、これまで投入部品量の予測や製造工期のスケジューリングを難しくすると共に装置価格の増大をもたらしていた。温度など装置が使用されている環境が変化した場合の調整や、装置の経時変化などに対する調整においても同様の問題があった。本発明はこれらの点に鑑みてなされたもので、投影露光装置に搭載する投影光学系に対し、柔軟性を持ち比較的簡単な構成で歪曲収差の多様な成分を補正し得る機構を提供することを目的とする。

【０００９】

【課題を解決するための手段】本発明においては、投影光学系を構成する光学素子自体に意図的に温度分布を与え、その光学素子を物理的に変形させせることで歪曲収差を補正することによって前記目的を達成する。

【００１０】すなわち、本発明は、レチクルを照明する照明系（ＩＵ）と、感光基板（Ｗ）を保持する基板ステージ（ＳＴ）と、レチクル（Ｒ）のパターン像を感光基板上に形成する投影光学系（ＰＬ）とを含む投影露光装置において、投影光学系（ＰＬ）を構成する光学素子（Ｌ１～Ｌ６）の温度を変化させる温度可変手段（Ｈ１，Ｈ２，ＨＰ１～ＨＰ８，ＳＣ）と、光学素子の温度分布を計測する温度計測手段（Ｓ１～Ｓ８，ＩＲ）と、温度計測手段によって計測された温度分布に基づいて温度可変手段を制御して光学素子に所定の温度分布を与えることにより投影光学系の収差を補正する温度分布制御手段（ＴＣ）とを備えることを特徴とする。

【００１１】温度可変手段は、光学素子に接触して熱伝導により光学素子に温度分布を与えるタイプのもの、又は光学素子に非接触で熱を与えるタイプのもののいずれも採用することができ、両タイプのものを組み合わせて用いることもできる。接触型の温度可変手段としては、投影光学系を構成する１つ又は複数の光学素子の外周に複数配設したヒーター（Ｈ１，Ｈ２）等の加熱手段又はヒートポンプ（ＨＰ１～ＨＰ８）等の加熱冷却手段を用いることができる。また、非接触型の温度可変手段としては、光学素子に所望のパターンで赤外線を照射する赤外線照射手段（ＳＣ）を用いることができる。

【００１２】温度計測手段としては、光学素子の周辺に配置された複数の熱電対等の温度センサ（Ｓ１～Ｓ８）を用いることができる。また、温度計測手段として赤外線撮像装置等からなる放射温度計（ＩＲ）を用いると、光学素子の中央部分の温度分布を非接触で計測することができる。もちろん、温度計測手段として、光学素子の周辺部の温度分布を計測する複数の熱電対と光学素子の中央部分の温度分布を計測する放射温度計とを組み合わせて用いてもよい。温度分布制御手段（ＴＣ）は、温度計測手段によって計測された光学素子の温度分布が所望の温度分布となるように温度可変手段を制御することで、高精度な制御を行うことができる。

【００１３】ヒーターやヒートポンプ等の接触型の温度可変手段は、光学素子の外周部に配設するため、レンズ鏡筒（Ｔ）の中央部分に配置された光学レンズ等どの位置の光学素子に対しても設置可能である。また、加熱能力を有するヒーター等に加えて冷却能力を有するヒートポンプ等を組み合わせて用いることにより、光学素子に大きな温度勾配を与えることが可能である。反面、光学素子の有効面積を広くとるためには取り付け位置が光学素子の外周部に限られ、光学素子の光軸に近い中央領域に直接熱伝達を行うことができないため、光学素子に付与することのできる温度分布パターンが制限されてしまう。

【００１４】これに対して、赤外線ビームスキャナ等の非接触型の温度可変手段は、光学素子の有効面積を狭めることなく光軸近くの領域に対しても直接熱を与えることができるため、光学素子に付与することのできる温度分布パターンの自由度が比較的大きい。しかしながら、赤外線ビームを照射することのできる光学素子は通常は投影光学系の上下両端部の光学素子に限られ、また光学素子を加熱することはできるが冷却することはできない。このように、接触型の温度可変手段と非接触型の温度可変手段とは相互に補完しあう機能を有し、両者を組み合わせて用いることで、それぞれを単独で用いる場合に比較してより高精度な投影光学系の収差補正が可能となる。

【００１５】投影光学系の歪曲収差（ディストーション）を補正するに当たっては、まず格子パターンなど既知のパターンを投影光学系によって結像面に投影し、結像されたパターンの歪みを計測することで投影光学系の収差を求める。次に、計測された収差を補正するためには投影光学系中のどの光学素子にどのような温度分布を与えるべきであるかを決定する。続いて、その温度分布を実現するために個々のヒーターに流すべき電流値等、温度分布制御手段による制御量を求めて制御を行うことになる。制御量は、解析的に求めることは困難であるため、実測データをもとにした線形演算によって、もしくはシミュレーションによって求める。

【００１６】図１及び図２を用いて、本発明による投影光学系の歪曲収差補正の原理について説明する。図１は、光学レンズＬ１，Ｌ２，Ｌ３からなる屈折型の投影光学系を模式的に示すものである。照明光ＩＬで一様に照明されたレチクルＲ上のパターンは、光学レンズ群Ｌ１～Ｌ３によりフォトレジスト等の感光剤を塗布されたウェハＷ上に結像される。光学レンズＬ３の外周には、ヒーターＨ１とＨ２が図示するように取り付けられている。

【００１７】ヒーターＨ１，Ｈ２に通電していない場合、光学レンズＬ３の温度は均一であり、その時のレチクルＲ上のパターンの物点Ｏに対するウェハＷ上の像点はＩである。いま、レチクルＲに図２（ａ）に示すよう

な格子状パターンPが形成されているとして、このパターンPを光学レンズ群L１～L３からなる投影光学系によってウエハW上に投影したとき、図２（b）に示すように歪曲されて結像したとする。このとき光学レンズL３の上方に取り付けられたヒーターH１に通電して発熱させると、光学レンズL３には温度分布が生じ加熱された部分が膨張して破線で示すL３’の様な形状になる。そのためにウエハW上の像の位置がずれ、物点Oに対する像点はI’になり、ウエハW上に図２（c）に示すように歪みのないパターン像が形成される。

【００１８】ヒーターH１とH２を同時に通電加熱することにより、光学レンズL３の周辺部分を中央部に比べて厚くすることもできる。この場合、光学レンズL３は凹レンズとして働き、像を拡大することが可能になる。また、ヒーターの代わりにペルチェ素子などのヒートポンプを使用し、光学レンズ周辺部を中央部に対して冷却することで、逆に光学レンズの周辺部分をを中心部に比べて薄くすることもできる。その場合には光学レンズL３は凸レンズとして働く。

【００１９】ここでは非常に単純化した例によって説明したが、実際にはヒーターH１への通電による光学レンズL３の温度分布、したがって対応する部分の像の位置ずれ量も複雑なものになる。そのため、光学レンズL３のそれぞれの部分の温度の差による歪曲収差の変動量を有限要素法による熱解析や光学シミュレーションなどで解析すると共に、温度を測定するためのセンサや温度分布を与えるための加熱手段や冷却手段の配置を十分検討することが必要である。また、光学レンズに対する熱的な外乱を防ぐことも重要である。

【００２０】本発明を屈折光学素子に適用する場合、光学素子の材料は歪曲収差の補正量に応じて物性を選び選択する必要がある。投影露光装置では近年の露光光の短波長化により光学素子として使用できる光学材料が限られているが、蛍石（CaF_2）は温度による線膨張率が比較的大きく、KrFやArFエキシマレーザなどから発生される紫外線に対する透過率も大きいため、本発明による投影光学系の光学材料として好適である。

【００２１】本発明は、従来、光学素子の相対位置を変えることで調整していた投影光学系の歪曲収差を、光学素子自体を動かすことなく光学素子の温度を変化させて物理的に変形させることで補正するものであるため、従来必要であった調整用の機械部品を省くことができ、構造の簡素化やコスト低減に効果的である。また、単に温度を変えるだけでなく温度分布を与えることで光学素子を局所的に変形させることが可能であるため、従来の方法では修正できなかった歪曲収差、例えば歪曲収差のうちの回転対称でない成分や比較的ランダムな成分をも修正することが可能となる。

【００２２】

【発明の実施の形態】以下、図面を参照して本発明の実施の形態を説明する。図３は、本発明による投影露光装置の第１の実施の形態を示す概略図である。投影露光装置は照明光学系IU、レチクルRを保持するレチクルステージRS、投影光学系PL、ウエハWを保持して２次元方向に移動可能なウエハステージSTを備え、装置全体は環境制御チャンバEC内に納められて一定温度になるよう空調制御されている。投影光学系PLは、この例では６枚の光学レンズL１～L６からなる屈折光学系で構成され、光学レンズL１～L６を保持するレンズ鏡筒Tは、より高精度な温度制御を行うために温度制御ジャケットTJで覆われている。

【００２３】照明光学系IUから射出された照明光ILは、投影されるパターンが描画されたレチクルRを均一に照明する。そしてレチクルRに描かれたパターンにより強度変調と回折を受けることで、パターンの情報を持って投影光学系PLに入射する。投影光学系PLは、レチクルRに描かれたパターンの像をウェハW上に形成する。

【００２４】投影光学系PLを構成する光学レンズのうち上端部の光学レンズL１の外周部分には、図４に示すように、ペルチェ素子などのヒートポンプHP１～HP８と温度センサS１～S８とが対になって空間的に対称に取り付けられている。それぞれのヒートポンプHP１～HP８は、温度センサS１～S８からの温度測定結果をもとに温度コントローラTCによって温度制御される。各ヒートポンプHP１～HP８を個別に加熱駆動もしくは冷却駆動して光学レンズ外周各部の温度を互いに変化させることにより、あるいは環境制御チャンバECや温度制御ジャケットTJの設定温度に対して変化させることにより、光学レンズL１に温度分布を発生させることができる。

【００２５】ヒートポンプHP１～HP８により光学レンズ外周部各点での温度を変えることにより、光学レンズL１に単に凹レンズや凸レンズとしての機能を付加するだけではなく、より複雑な非球面レンズとしての機能を持たせることも可能である。例えば、光軸を挟んで対向配置されたヒートポンプHP１とHP５の位置で光学レンズL１の温度を上げ、それと直交するように対向配置されたヒートポンプHP３とHP７の位置の温度を逆に下げることにより、非回転対称な歪曲収差の補正も可能である。このほかにも発生させる温度の組み合わせを変えることにより、さらに複雑な形状の歪曲収差にも対応することが可能である。

【００２６】温度コントローラTCに付随してROMや磁気ディスク等の記憶装置Mが設けられ、記憶装置Mには光学レンズL１の温度分布と投影光学系PLの歪曲収差の変動量の関係を示すデータが記憶されている。このデータは、実測又はシミュレーションによって求めることができる。実測によるデータの収集は、投影光学系PLを構成する光学レンズL１にある温度分布を与え、そ

の温度分布を与えた状態で図２（ａ）に示すような格子状パターンを有するレチクルＲの像を像面に投影し、投影されたパターンの設計位置からのずれ量を計測することを温度分布を変えながら反復することで行うことができる。また、シミュレーションによるデータ収集は、各光学素子に種々の温度分布を与えたときの歪曲収差の変動量を有限要素法による熱解析や光学シミュレーションなどで解析することにより行うことができる。

【００２７】温度コントローラＴＣによる各ヒートポンプＨＰ１～ＨＰ８の制御量は、図２（ａ）に示すような格子状パターンを投影して投影光学系ＰＬの歪曲収差を計測し、その収差を補正するのに必要な温度分布を記憶装置Ｍに記憶されているデータから線形演算によって求めることで決定される。温度コントローラＴＣは、こうして決定された制御量を用い、温度センサＳ１～Ｓ８の出力をモニターしながら各ヒートポンプＨＰ１～ＨＰ８を制御することにより投影光学系ＰＬの歪曲収差を補正する。

【００２８】図５は、本発明による投影露光装置の第２の実施の形態を示す概略図である。図５に示す第２の実施の形態の装置は、図３に示した第１の実施の形態の装置に加えて赤外線ビームスキャナＳＣ及び２次元ＣＣＤ赤外線撮像装置などの放射温度計ＩＲを備え、また記憶装置に代えてシミュレーション装置ＳＭを備えたものである。図５において、図３に示したのと同様の機能を果たす部分には図３と同一の番号を付して詳細な説明を省略する。

【００２９】赤外線ビームスキャナＳＣは、投影光学系ＰＬの上端部に露出する光学レンズＬ１の表面を赤外線ビームの強度を変化させながら高速に走査することで、光学レンズＬ１に対して所望のパターンで熱を与えることができるものである。つまり、光学レンズＬ１は、図４に示すように光学レンズ外周部に配置されたヒートポンプＨＰ１～ＨＰ８による温度制御と同時に赤外線ビームの照射による温度制御を受ける。赤外線ビームスキャナＳＣは、ヒートポンプによっては不可能であった光学レンズＬ１の光軸近くの領域にも熱を与えることができるため、ヒートポンプＨＰ１～ＨＰ８のみによる温度制御に比べてより精度の高い温度制御が可能となる。赤外線ビームスキャナＳＣによって走査される赤外線の波長は光学レンズＬ１を形成している光学ガラス材料が強い吸収を示す波長に設定するのが好ましい。光学レンズＬ１が強い吸収を示す波長の赤外線を使用することにより、他の光学レンズＬ２～Ｌ６に影響を与えることなく必要な光学レンズＬ１のみに熱を与えることができる。なお、赤外線ビームスキャナに代えて、所望の強度パターン（例えば、中央部が強く、周辺部が弱い強度の円形パターン）を有する赤外線光束を光学レンズＬ１に照射する照明手段を照明光学系ＩＵ中に設けても同様の効果を上げることができる。

【００３０】また、放射温度計ＩＲを用いることにより、光学レンズＬ１の外周部に配置した温度センサＳ１～Ｓ８では測定することができなかった光学レンズ中心部も含めた光学レンズＬ１全体の温度分布を測定することができる。

【００３１】シミュレーション装置ＳＭは、有限要素法などの手法により、光学レンズＬ１の温度分布を与えることで投影光学系ＰＬの結像特性をシミュレートする機能を有するものとすることができる。投影光学系ＰＬの歪曲収差補正に当たっては、まず既知のパターンを投影することによって投影光学系ＰＬの歪曲収差を計測し、計測された歪曲収差の補正に必要な光学レンズＬ１の温度分布をシミュレーション装置ＳＭを用いて求める。温度コントローラＴＣは、放射温度計ＩＲによる光学レンズＬ１の温度分布を実時間で監視しながら、その温度分布がシミュレーション装置ＳＭで求められた温度分布に一致するように光学レンズＬ１の外周部に付設されたヒートポンプＨＰ１～ＨＰ８及び赤外線ビームスキャナＳＣを制御することによって、投影光学系ＰＬの光学特性を修正し歪曲収差を補正する。

【００３２】また、シミュレーション装置ＳＭは、光学レンズＬ１に配設されたヒートポンプＨＰ１～ＨＰ８への通電量や赤外線ビームスキャナＳＣによる光学レンズＬ１への赤外線照射パターンなど、温度コントロータＴＣによる制御パラメータを入力することで、有限要素法などの方法によって投影光学系ＰＬの結像特性をシミュレートする機能を有するものとすることもできる。この場合には、シミュレーション装置ＳＭに種々の制御パラメータを入力し、投影光学系ＰＬの歪曲収差がどのように変化するかをシミュレーションすることで最適な制御パラメータを見出すことができる。温度コントローラＴＣは、その最適パラメータに従って温度可変手段を制御すればよい。

【００３３】あるいは、シミュレーション装ＳＭ置に実測された投影光学系ＰＬの歪曲収差データを入力し、その歪曲収差を補正するのに最適な制御パラメータが自動的に出力されるようにシミュレーション装置ＳＭを自動運転することもできる。

【００３４】このように投影露光装置自体にシミュレーション装置ＳＭを搭載することで、リアルタイムで温度分布パターンを変化させることが可能である。事前に計算しておいた有限要素法などによるシミュレーション結果を使用する場合でも、蛍石などの比較的線膨張率の大きい光学材料では実際に与える温度差が少ないことから熱的な計算部分を線形演算で近似することが可能になり柔軟性の高い設定が可能になる。また変形量が微少であるか、誤差を許容できるならば、蛍石に関わらずあらゆる光学材料についても適用できる。

【００３５】ここでは、投影光学系を構成する光学素子のうち上端部の光学レンズＬ１にのみヒートポンプや赤

外線スキャナ等の温度可変手段を付与する例を説明した。温度可変手段を設ける光学素子は、一般には物体もしくは像に近い光学素子とするのが有利であり、縮小投影型の投影光学系においては物体側の光学素子とするのが有利である。しかし、温度可変手段を付設する光学素子は投影光学系の上端や下端の光学素子に限られるものではなく、鏡筒内部の光学素子に設けることもできるし、同時に複数の光学素子に付設することもできる。

【0036】また、温度可変手段の例として、ヒータ、ペルチェ素子等のヒートポンプ、赤外線ビームスキャナをあげたが、その他にノズル先端から温風又は熱風を吹き付けたり、マイクロ波照射によって光学素子の温度分布を制御することもできる。

【0037】

【発明の効果】本発明によれば、投影露光装置に搭載する投影光学系に対し、比較的簡単な構成で歪曲収差の多様な成分を補正することができる。

【図面の簡単な説明】

【図１】本発明による投影光学系の歪曲収差補正の原理を説明する図。

【図２】レチクルのパターンとその像を示す図。

【図３】本発明による投影露光装置の一例を示す概略図。

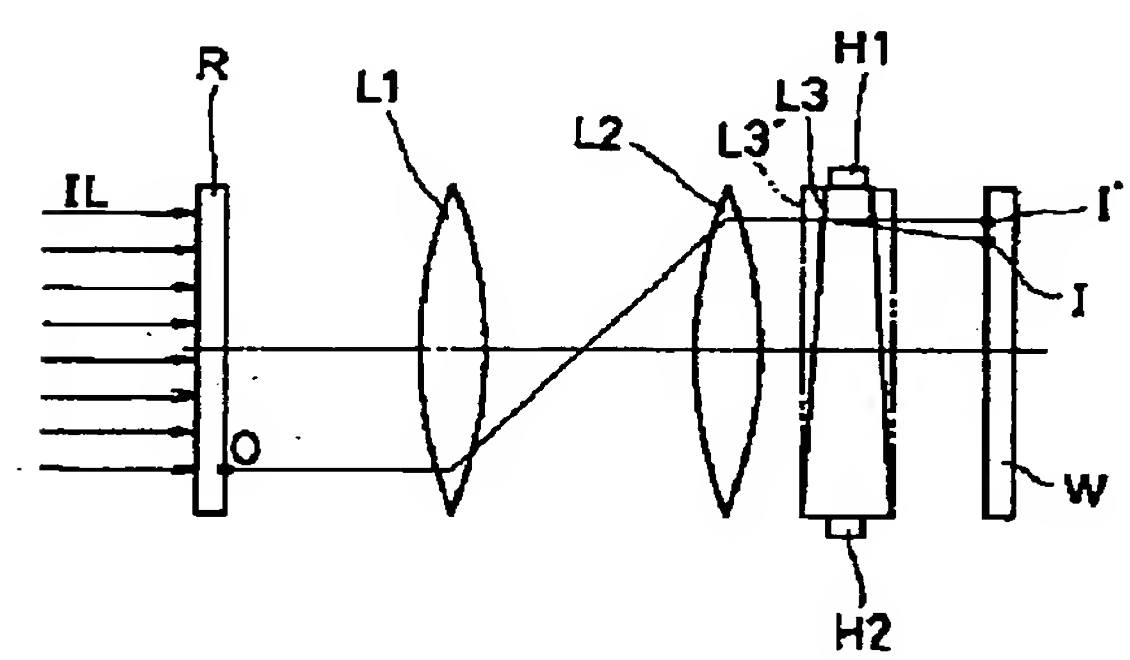
【図４】ヒートポンプと温度センサが取り付けられた光学レンズの模式図。

【図５】本発明による投影露光装置の他の例を示す概略図。

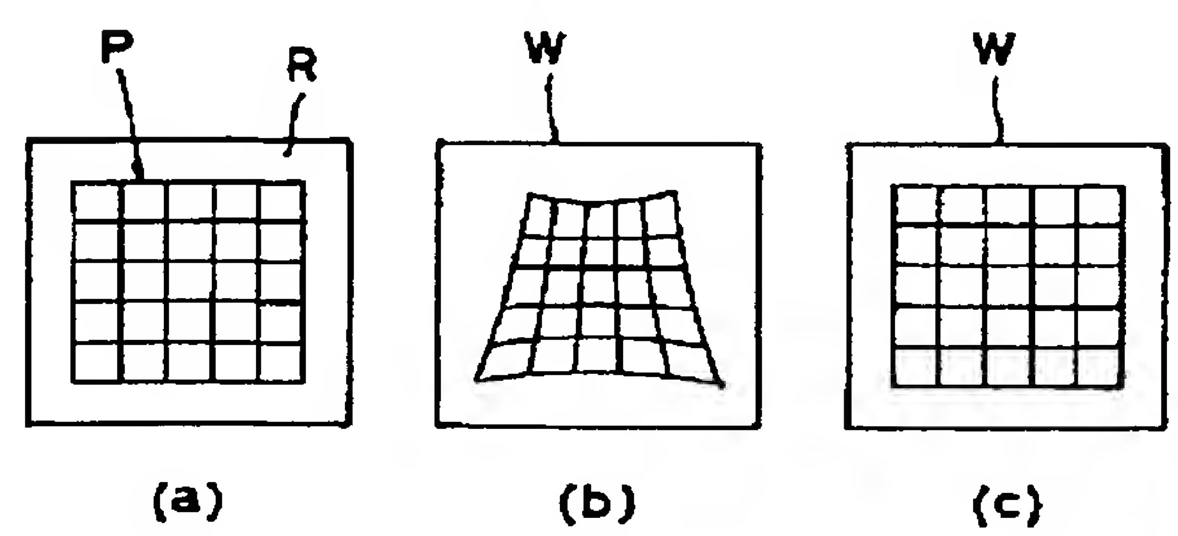
【符号の説明】

ＥＣ…環境制御チャンバ
Ｈ１，Ｈ２…ヒーター
ＨＰ１～ＨＰ８…ヒートポンプ
Ｉ…像点
ＩＬ…照明光
ＩＲ…放射温度計
ＩＵ　照明光学系
Ｌ１～Ｌ６…光学レンズ
Ｍ…記憶装置
Ｏ…物点
ＰＬ…投影光学系
Ｒ…レチクル
ＲＳ…レチクルステージ
Ｓ１～Ｓ８…温度センサ
ＳＭ…シミュレーション装置
ＳＴ…ウエハステージ
Ｔ…レンズ鏡筒
ＴＣ…温度コントローラ
ＴＪ…温度制御ジャケット
Ｗ…ウェハ

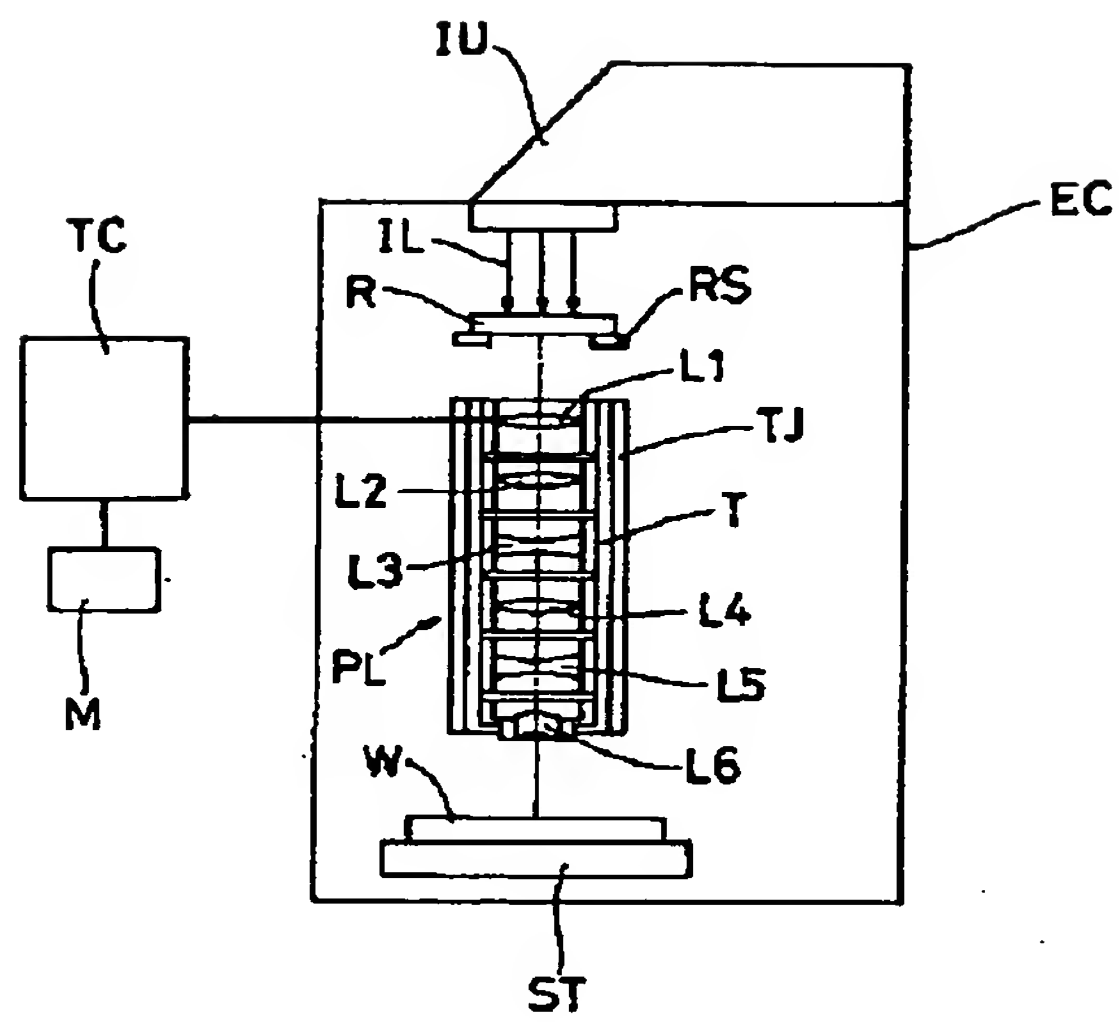
【図１】



【図２】



【図３】


IU
EC
TC
IL
R
RS
L1
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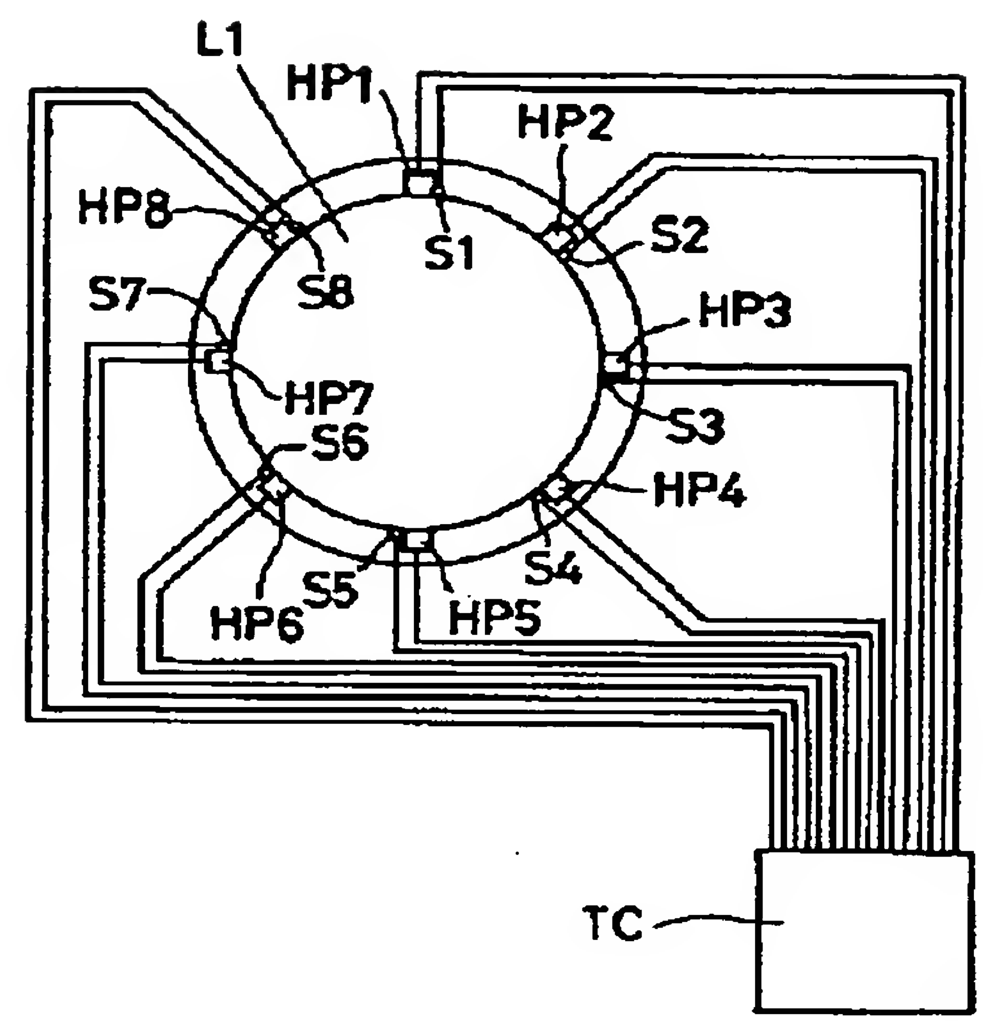
L2
T
L3
L4
PL
L5
M
W
L6
ST

【図４】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HP2
HP8
S8
S1
S2
S7
HP3
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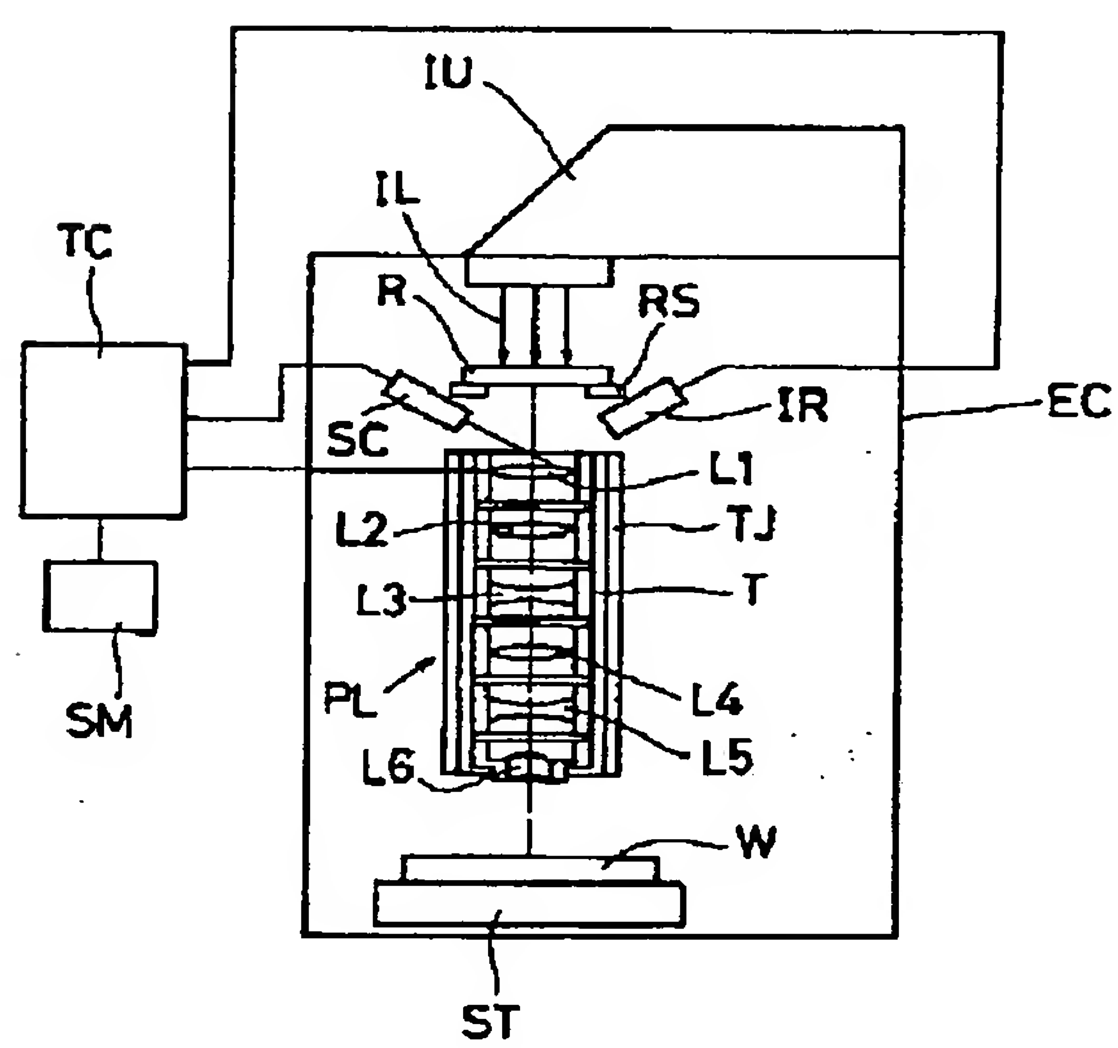
S6
S3
HP4
S5
S4
HP6
HP5
TC

【図５】


IU
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PATENT ABSTRACTS OF JAPAN

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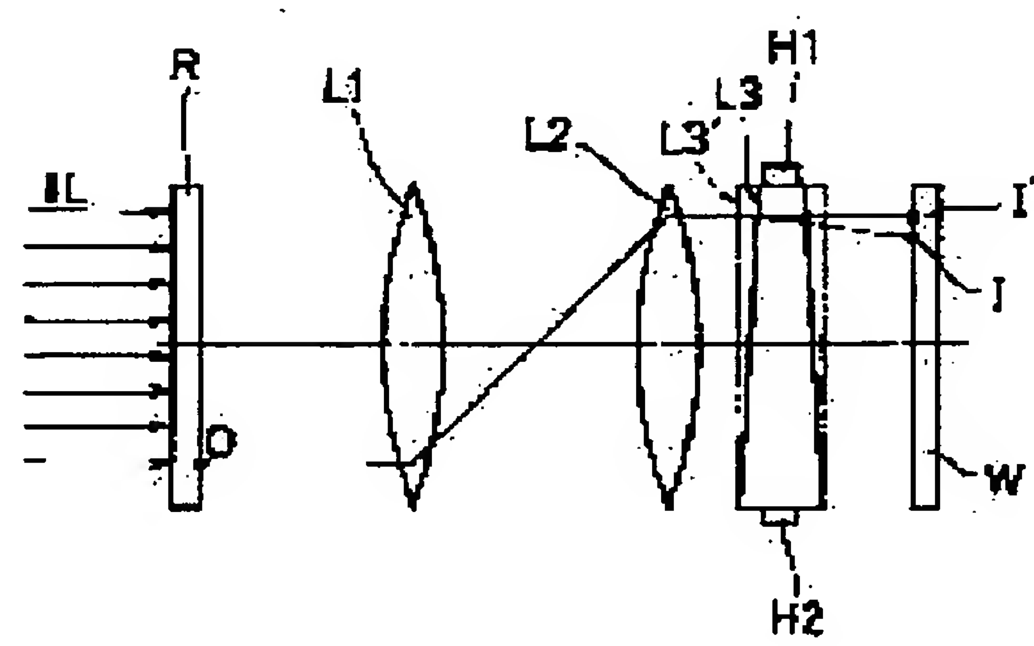
(54) PROJECTION ALIGNER

(57)Abstract:
PROBLEM TO BE SOLVED: To obtain a projection aligner which omits a machine component for adjustment, whose structure is simplified and whose costs are reduced by a method wherein a temperature-variable means is controlled on the basis of a measured temperature distribution, a prescribed temperature distribution is given to an optical element and the aberration of a projection optical system is corrected.
SOLUTION: Heaters H1 and H2 are attached to the outer circumference of an optical lens L3. When the respective heaters H1, H2 are not electrified, the temperature distribution of the optical lens L3 is measured by a temperature sensor, its temperature is made uniform, and an image point on a wafer W with reference to the object point O of a pattern on a reticle R is set at I. In addition, a lattice-shaped pattern P is image-formed on the wafer W so as to be distorted by a projection optical system which is composed of a group of optical lenses L1 to L3, the heater H1 is electrified on the basis of the temperature distribution measured by the temperature sensor so as to generate heat, the heated part of the optical lens L3 is expanded so as to become a shape L3', an image point with reference to the object point O is set at I', and a distortion is corrected. Consequently, a machine component for adjustment can be omitted.



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[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	

CLAIMS

[Claim(s)]
[Claim 1] In a projection aligner including the illumination system which illuminates reticle, the substrate stage holding a sensitization substrate, and the projection optical system which forms the pattern image of said reticle on said sensitization substrate A temperature adjustable means to change the temperature of the optical element which constitutes said projection optical system, A thermometry means to measure the temperature distribution of said optical element, The projection aligner characterized by having the temperature-distribution control means which amends the aberration of said projection optical system by controlling said temperature adjustable means based on the temperature distribution measured by said thermometry means, and giving predetermined temperature distribution to said optical element.
[Claim 2] The projection aligner according to claim 1 characterized by having two or more heat pump arranged in the periphery of one or more optical elements which constitute said projection optical system as said temperature adjustable means.
[Claim 3] The projection aligner according to claim 1 or 2 characterized by equipping said optical element with an infrared exposure means to irradiate infrared radiation by the desired pattern, as said temperature adjustable means, and having a radiation thermometer as said thermometry means.
[Claim 4] The projection aligner according to claim 1 characterized by having the storage means which the temperature distribution of said optical element and the optical property of said projection optical system were made to correspond, and was memorized.
[Claim 5] It is the projection aligner according to claim 1 which is equipped with a simulation means to simulate the image formation property of said projection optical system as a control result of said temperature adjustable means by said temperature-distribution control means, and is characterized by said temperature-distribution control means controlling said temperature adjustable means based on the result of the simulation by said simulation means.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the projection aligner used for manufacture of a semiconductor device, a liquid crystal display, etc.
[0002]
[Description of the Prior Art] At the photograph RISOGURAFU process of manufacturing a semiconductor device, a liquid crystal display, the thin film magnetic head, etc., carrying out projection exposure of the pattern formed in a photo mask or reticle (henceforth reticle) using the projection aligner on sensitization substrates, such as a wafer with which it was applied to sensitization agents, such as a photoresist, and a glass plate, is performed. It repeats piling up and exposing this pattern exposure on the pattern already formed on the sensitization substrate two or more times, and, usually it is performed. Since the precision of the pattern formed on the sensitization substrate has direct effect on the engine performance of the device which is a finished product, it is required that the projection optical system of a projection aligner should make distortion of an image (distortion aberration) very small. Therefore, it is needed for making very small distortion aberration theoretically produced in the case of the design of a projection lens to, make small ******, and the manufacture error and assembly tolerance of the optical element produced in the case of manufacture of course. Moreover, since the aberration of a projection optical system is changed by change of environmental parameters, such as an atmospheric pressure and temperature, the temperature change of the optical element by absorbing exposure light at the time of exposure, etc., the amendment to these fluctuation is also required.
[0003] The following has been performed in order to suppress conventionally the error produced at the time of manufacture of a projection aligner. One is reduction of the error of the optical element itself to be used. For example, in case the optical element (the so-called optical lens) of a refraction mold is manufactured, efforts that the thing near the ideal value on an optical design will be completed have been made by using the high optical material of refractive-index homogeneity, and processing it in a very high precision. Moreover, achievement of the designed engine performance has been achieved by adding a device to mounting so that it may be held at exact physical relationship, without the completed optic producing deformation.
[0004] However, in manufacture of the projection optical system of a projection aligner, since the very advanced engine performance is required, it happens to cross the limitation of process tolerance that the manufacture precision demanded from each components is acquired with a current technique. Therefore, the actual condition has taken the technique of making the engine performance required as the whole projection optical system attain by trial and error by repeating adjustment to each part of the optical system which could not obtain the required engine performance only by the above approaches, but was composed eventually.
[0005] Moreover, to fluctuation of the aberration produced by change of an operating environment etc., by making a part of approach of isolating from change of an external environment and protecting by putting in the whole projection optical system in an ECS, or covering a projection optical system in a temperature control jacket, or projection optical system into sealing structure, the atmospheric pressure of the part was controlled and the configuration which compensates fluctuation of the aberration by the environmental variation by the approach of moving some optical elements had been taken.
[0006]
[Problem(s) to be Solved by the Invention] There are the following problems in the conventional projection aligner mentioned above. That is, although compensated with adjusting conventionally about the projection

optical system eventually assembled to the error produced at the time of manufacture, it cannot adjust on the product a high precision was needed also for the adjustment, and setting up was finished about all engine performance.
[0007] In amendment of the distortion aberration (distortion) of a projection optical system, by adjusting the distance between the optical elements which constitute a projection optical system by several places to amendment of a symmetry-of-revolution component, most can be corrected and it can correct by moving an optical element in three dimension also about a component symmetrical with some nonrotation. However, it was very difficult from fields, such as precision and access nature, to correct about all components after completion of a product.
[0008] Moreover, when the case where the optical-glass material which forms an optical element has refractive-index distribution, and the attaching part article had deformed, when not decomposed and exchanged to the level of the components which constitute optical system, while there is also an uncorrectable thing and making difficult prediction of the amount of charge components, and scheduling of a manufacture construction period until now, buildup of an equipment price was brought about. There was same problem also in the adjustment to adjustment when the environment where equipments, such as temperature, are used changes, aging of equipment, etc. This invention was made in view of these points, and aims at offering the device which can amend the various components of distortion aberration with a comparatively easy configuration with flexibility to the projection optical system carried in a projection aligner.
[0009]
[Means for Solving the Problem] In this invention, temperature distribution are intentionally given to the optical element itself which constitutes a projection optical system, and said object is attained by amending distortion aberration by making the optical element deform physically.
[0010] Namely, this invention is set to a projection aligner including the illumination system (IU) which illuminates reticle, and the projection optical system (PL) which forms the substrate stage (ST) holding a sensitization substrate (W), and the pattern image of reticle (R) on a sensitization substrate. A temperature adjustable means to change the temperature of the optical element (L1 - L6) which constitutes a projection optical system (PL) (H1, H2, HP1- HP8, SC), A thermometry means to measure the temperature distribution of an optical element (S1- S8, IR), It is characterized by having the temperature-distribution control means (TC) which amends the aberration of a projection optical system by controlling a temperature adjustable means based on the temperature distribution measured by the thermometry means, and giving predetermined temperature distribution to an optical element.
[0011] Either the thing of a type which contacts an optical element and gives temperature distribution to an optical element by heat conduction, or the thing of a type which gives heat to an optical element by non-contact can be used for a temperature adjustable means, and it can also be used combining the thing of both types. Heating cooling means, such as heating means, such as a heater (H1, H2) arranged in the periphery of one or more optical elements which constitute a projection optical system as a temperature adjustable means of a contact mold, or heat pump (H.P.1-HP8), can be used. [two or more] Moreover, as a temperature adjustable means of a non-contact mold, an infrared exposure means (SC) to irradiate infrared radiation by the desired pattern can be used for an optical element.
[0012] As a thermometry means, temperature sensors (S1-S8), such as two or more thermocouples arranged around an optical element, can be used. Moreover, if the radiation thermometer (IR) which consists of infrared image pick-up equipment etc. as a thermometry means is used, the temperature distribution for a center section of an optical element are measurable by non-contact. Of course, you may use as a thermometry means combining two or more thermocouples which measure the temperature distribution of the periphery of an optical element, and the radiation thermometer which measures the temperature distribution for a center section of an optical element. A temperature-distribution control means (TC) can perform highly precise control by controlling a temperature adjustable means so that the temperature distribution of the optical element measured by the thermometry means turn into desired temperature distribution.
[0013] Since it arranges in the periphery section of an optical element, the temperature adjustable means of contact molds, such as a heater and heat pump, can be installed also to the optical element of which locations, such as an optical lens arranged at a part for the center section of a lens barrel (T). Moreover, it is possible to give a big temperature gradient to an optical element by using combining the heat pump which has refrigeration capacity in addition to the heater which has heating capacity. Since an installation location is restricted to the periphery section of an optical element on the other hand in order to take a large effective

area of an optical element, and heat transfer cannot be directly performed to the central field near the optical axis of an optical element, the temperature-distribution pattern which can be given to an optical element will be restricted.

[0014] On the other hand, since the temperature adjustable means of non-contact molds, such as an infrared beam scanner, can give direct heat also to the field near the optical axis, without narrowing the effective area of an optical element, its degree of freedom of the temperature-distribution pattern which can be given to an optical element is comparatively large. However, although the optical element which can irradiate an infrared beam is usually restricted to the optical element of the vertical both ends of a projection optical system and can heat an optical element, it cannot be cooled. Thus, the temperature adjustable means of a contact mold and the temperature adjustable means of a non-contact mold are having the function which complements mutually and suits it and using combining both, and aberration amendment of a highly precise projection optical system is attained as compared with the case where each is used independently.

[0015] In amending the distortion aberration (distortion) of a projection optical system, the aberration of a projection optical system is searched for by projecting known patterns, such as a grid pattern, on an image formation side according to a projection optical system first, and measuring the distortion of a pattern by which image formation was carried out. Next, in order to amend the measured aberration, it is determined what kind of temperature distribution should be given to which optical element in a projection optical system. Then, it will control in quest of controlled variables by the temperature-distribution control means, such as a current value which should be passed at each heater in order to realize the temperature distribution. the linearity operation based on location survey data since asking analytically is difficult the controlled variable -- or it asks by simulation.

[0016] The principle of distortion aberration amendment of the projection optical system by this invention is explained using drawing 1 and drawing 2 . Drawing 1 shows typically the projection optical system of the refraction mold which consists of optical lenses L1, L2, and L3. Image formation of the pattern on the reticle R uniformly illuminated by the illumination light IL is carried out on the wafer W to which sensitization agents, such as a photoresist, were applied by the optical lens groups L1-L3. It is attached in the periphery of an optical lens L3 so that heaters H1 and H2 may illustrate.

[0017] When not energizing at heaters H1 and H2, the temperature of an optical lens L3 is uniform, and the image point on the wafer W to the object point O of the pattern on the reticle R at that time is I. When you project this pattern P on Wafer W according to the projection optical system which consists of optical lens groups L1-L3 noting that the grid-like pattern P as shown in Reticle R at drawing 2 (a) is formed now, as shown in drawing 2 (b), it is distorted and suppose that image formation was carried out. If it energizes at the heater H1 attached above the optical lens L3 at this time and it is made to generate heat, it will become a configuration like L3' which the part in which temperature distribution arose and were heated expands to an optical lens L3, and is shown with a broken line. Therefore, the pattern image which the location of the image on Wafer W shifts and the image point to the object point O becomes I', and does not have distortion as shown on Wafer W at drawing 2 (c) is formed.

[0018] By carrying out energization heating of the heaters H1 and H2 simultaneously, the circumference part of an optical lens L3 can also be thickened compared with a center section. In this case, an optical lens L3 works as a concave lens, and it becomes possible to expand an image. Moreover, heat pump, such as a Peltier device, can be used instead of a heater, and circumference ****** of an optical lens can also be made thin by cooling an optical lens periphery to a center section at reverse compared with a core. In that case, an optical lens L3 works as a convex lens.

[0019] Although the example simplified dramatically explained here, the amount of location gaps of the temperature distribution of the optical lens L3 by the energization to a heater H1, therefore the corresponding image of a part will also become complicated actually. Therefore, while analyzing the amount of fluctuation of the distortion aberration by the difference of the temperature of each part of an optical lens L3 in thermal analysis, optical simulation, etc. by the finite element method, it is required to consider enough arrangement of the heating means for giving the sensor and temperature distribution for measuring temperature or a cooling means. Moreover, it is also important to prevent the thermal disturbance over an optical lens.

[0020] When applying this invention to a refraction optical element, the ingredient of an optical element needs to choose and choose physical properties according to the amount of amendments of distortion aberration. Although the optical material which can be used as an optical element by short wavelength-ization of an exposure light in recent years is restricted in the projection aligner, since the coefficient of linear expansion of fluorite (CaF_2) by temperature is comparatively large and its permeability to the

ultraviolet rays generated from KrF, ArF excimer laser, etc. is also large, it is suitable as an optical material of the projection optical system by this invention.

[0021] Since this invention is what is amended by changing the temperature of an optical element and making it deform physically, without moving the optical element itself for the distortion aberration of the projection optical system which was being adjusted by changing the relative position of an optical element conventionally, it can exclude the machine part for adjustment which was the need conventionally, and is effective for the simplification and cost reduction of structure. Moreover, since it is possible to make an optical element deform locally by it not only to changing temperature, but giving temperature distribution, by the conventional approach, it becomes possible to also correct the component which is not the symmetry of revolution of the distortion aberration which was not able to be corrected, for example, distortion aberration, and a comparatively random component.

[0022]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained with reference to a drawing. Drawing 3 is the schematic diagram showing the gestalt of operation of the 1st of the projection aligner by this invention. A projection aligner holds the reticle stage RS holding the illumination-light study system IU and Reticle R, a projection optical system PL, and Wafer W, and is equipped with the movable wafer stage ST in the two-dimensional direction, and air conditioning control of the whole equipment is carried out so that it may be dedicated in the environmental control chamber EC and may become constant temperature. It consists of dioptric system which a projection optical system PL turns into from six optical lenses L1 - L6 in this example, and in order that lens barrel T holding an optical lens L1 - L6 may perform highly precise temperature control, it is covered in the temperature control jacket TJ.

[0023] The illumination light IL injected from the illumination-light study system IU illuminates the reticle R by which the pattern projected was drawn to homogeneity. And by receiving intensity modulation and diffraction with the pattern drawn on Reticle R, it has the information on a pattern and incidence is carried out to a projection optical system PL. A projection optical system PL forms the image of the pattern drawn on Reticle R on Wafer W.

[0024] As shown in the periphery part of the optical lens L1 of a up edge at drawing 4 among the optical lenses which constitute a projection optical system PL, heat pump HP1-HP8 and temperature sensors S1-S8, such as a Peltier device, become a pair, and are spatially attached in the symmetry. Temperature control of each heat pump HP1-HP8 is carried out by temperature-controller TC based on the thermometry result from temperature sensors S1-S8. An optical lens L1 can be made to generate temperature distribution heating-driven or cooling driving each heat pump HP1-HP8 according to an individual, and changing mutually the temperature of each part of an optical lens periphery, or by making it change to the laying temperature of the environmental control chamber EC and the temperature control jacket TJ.

[0025] By changing the temperature in optical lens periphery section each point by heat pump HP1-HP8, it is possible it not only to add the function as a concave lens or a convex lens, but to give the function as a more complicated aspheric lens to an optical lens L1. For example, amendment of distortion aberration symmetrical with nonrotation is also possible by lowering the temperature of the location of the heat pump HP3 and HP7 by which opposite arrangement was carried out so that the temperature of an optical lens L1 might be intersected perpendicularly with raising and it in the location of the heat pump HP1 and HP5 by which opposite arrangement was carried out on both sides of the optical axis to reverse. In addition, by changing the combination of the temperature to generate, it is possible to deal also with the distortion aberration of a still more complicated configuration.

[0026] The storage M, such as ROM and a magnetic disk, is formed along with temperature-controller TC, and the data which show the temperature distribution of an optical lens L1 and the relation of the amount of fluctuation of the distortion aberration of a projection optical system PL to Storage M are memorized. It can ask for this data by location survey or simulation. Collection of the data based on location survey can be performed by repeating projecting the image of the reticle R which has a grid-like pattern where it gave the temperature distribution in the optical lens L1 which constitutes a projection optical system PL and the temperature distribution are given, as shown in drawing 2 (a) on the image surface, and measuring the amount of gaps from the design location of the projected pattern, changing temperature distribution. Moreover, data collection by simulation can be performed by analyzing the amount of fluctuation of the distortion aberration when giving various temperature distributions to each optical element in thermal analysis, optical simulation, etc. by the finite element method.

[0027] The controlled variable of each heat pump HP1-HP8 by temperature-controller TC projects a grid-like pattern as shown in drawing 2 (a), measures the distortion aberration of a projection optical system PL,

and is determined by searching for temperature distribution required amending the aberration by the linearity operation from the data memorized by Store M. Temperature-controller TC amends the distortion aberration of a projection optical system PL by controlling each heat pump HP1-HP8 using the controlled variable determined in this way, acting as the monitor of the output of temperature sensors S1-S8.

[0028] Drawing 5 is the schematic diagram showing the gestalt of operation of the 2nd of the projection aligner by this invention. In addition to the equipment of the gestalt of the 1st operation which is shown in drawing 5 and which showed the equipment of the gestalt of the 2nd operation to drawing 3 , it has the radiation thermometers IR, such as the infrared beam scanner SC and two-dimensional CCD infrared image pick-up equipment, and it replaces with storage and has simulation equipment SM. In drawing 5 , the same number as drawing 3 is given to the part which achieves the function same with having been shown in drawing 3 , and detailed explanation is omitted.

[0029] The infrared beam scanner SC can give heat by the desired pattern to an optical lens L1 by scanning the front face of the optical lens L1 exposed to the upper bed section of a projection optical system PL at a high speed, changing the reinforcement of an infrared beam. That is, an optical lens L1 receives the temperature control by the exposure of an infrared beam in the temperature control and coincidence by the heat pump HP1-HP8 arranged at the optical lens periphery section as shown in drawing 4 . Since the infrared beam scanner SC can also give heat to the field near the optical axis of the impossible optical lens L1 depending on heat pump, compared with the temperature control only by heat pump HP1-HP8, the temperature control with a more high precision of it becomes possible. As for the wavelength of the infrared radiation scanned with the infrared beam scanner SC, it is desirable to set it as the wavelength which shows absorption with the strong optical-glass ingredient which forms the optical lens L1. When an optical lens L1 uses the infrared radiation of wavelength in which strong absorption is shown, heat can be given only to the required optical lens L1, without affecting other optical lenses L2 - L6. In addition, it replaces with an infrared beam scanner, and the same effectiveness can be raised even if it establishes a lighting means to irradiate the infrared flux of light which has a desired pattern (for example, a center section being strong circular pattern of reinforcement with a weak periphery) on the strength at an optical lens L1, into the illumination-light study system IU.

[0030] Moreover, with the temperature sensors S1-S8 arranged in the periphery section of an optical lens L1, the temperature distribution of the optical lens L1 whole also including the optical lens core which was not able to be measured can be measured by using a radiation thermometer IR.

[0031] Simulation equipment SM shall have the function which simulates the image formation property of a projection optical system PL by giving the temperature distribution of an optical lens L1 by technique, such as the finite element method. In distortion aberration amendment of a projection optical system PL, by projecting a known pattern first, the distortion aberration of a projection optical system PL is measured, and the temperature distribution of the optical lens L1 required for amendment of the measured distortion aberration are searched for using simulation equipment SM. Supervising the temperature distribution of the optical lens L1 by the radiation thermometer IR in the real time, by controlling the heat pump HP1-HP8 and the infrared beam scanner SC which were attached to the periphery section of an optical lens L1 so that it might be in agreement with the temperature distribution asked for the temperature distribution with simulation equipment SM, temperature-controller TC corrects the optical property of a projection optical system PL, and amends distortion aberration.

[0032] Moreover, simulation equipment SM shall have the function which the infrared exposure pattern to the optical lens L1 with the amount of energization to heat pump HP1-HP8 and the infrared beam scanner SC which were arranged by the optical lens L1 etc. is inputting the control parameter by the temperature conte rotor TC, and simulates the image formation property of a projection optical system PL by approaches, such as the finite element method. In this case, various control parameters can be inputted into simulation equipment SM, and the optimal control parameter can be found out by carrying out simulation of how the distortion aberration of a projection optical system PL changes. Temperature-controller TC should just control a temperature adjustable means according to the optimal parameter.

[0033] Or the distortion aberration data of the projection optical system PL surveyed by simulation ** SM ** can be inputted, and unattended operation of the simulation equipment SM can also be carried out so that the optimal control parameter for amending the distortion aberration may be outputted automatically.

[0034] Thus, it is possible to change a temperature-distribution pattern on real time by carrying simulation equipment SM in the projection aligner itself. Even when using the simulation result by the finite element method calculated in advance, in optical materials with a comparatively large coefficient of linear expansion, such as fluorite, the temperature gradient given actually is enabled to approximate a thermal

count part by the linearity operation from few things, and high setting out of flexibility is attained. Moreover, if deformation is very small or an error can be permitted, it is not concerned with fluorite but can apply also about all optical materials.
[0035] Here, the example which gives temperature adjustable means, such as heat pump and an infrared scanner, only to the optical lens L1 of a up edge among the optical elements which constitute a projection optical system was explained. Generally, as for the optical element which establishes a temperature adjustable means, it is advantageous to consider as the optical element near a body or an image, and it is advantageous to consider as the optical element by the side of a body in the projection optical system of a cutback projection mold. However, the optical element which attaches a temperature adjustable means is not restricted to the optical element of the upper bed of a projection optical system, or a soffit, can also be prepared in the optical element inside a lens-barrel, and can also be simultaneously attached to two or more optical elements.
[0036] Moreover, as an example of a temperature adjustable means, although heat pump, such as a heater and a Peltier device, and an infrared beam scanner were raised, warm air or hot blast can be sprayed from a nozzle head, or the temperature distribution of an optical element can also be controlled by microwave exposure.
[0037]
[Effect of the Invention] According to this invention, the various components of distortion aberration can be amended with a comparatively easy configuration to the projection optical system carried in a projection aligner.

[Translation done.]

* NOTICES *

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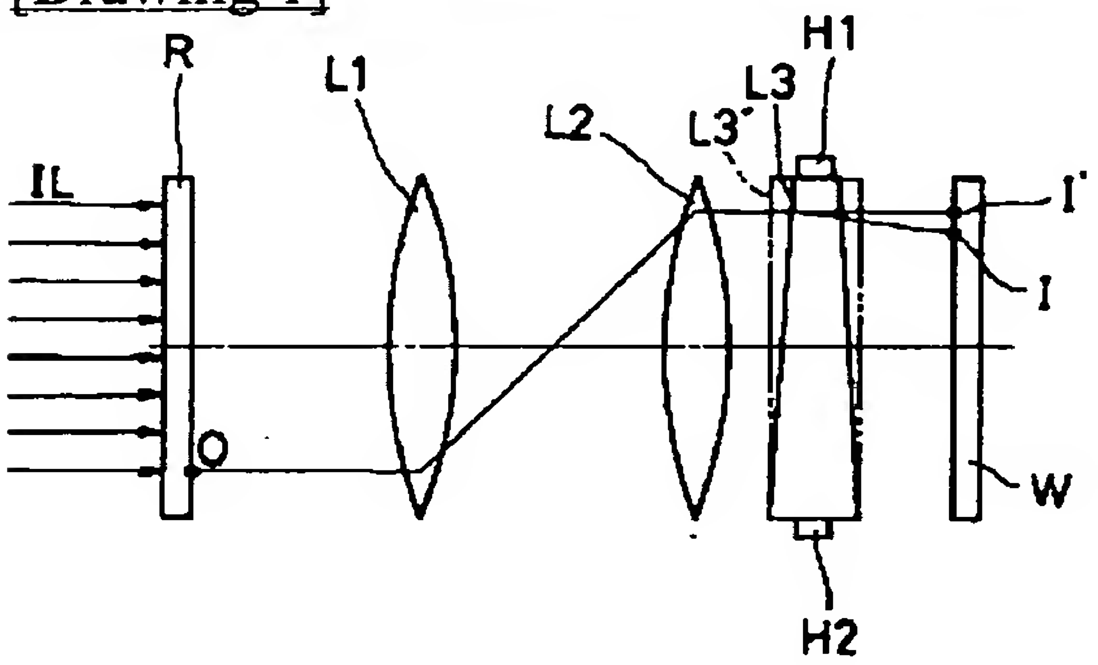
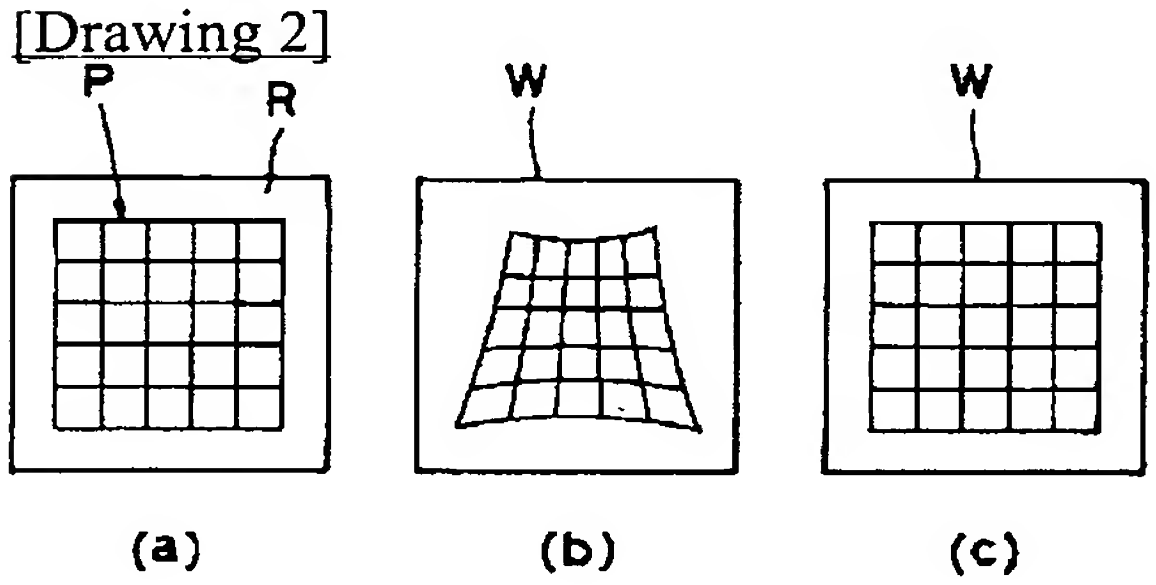
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

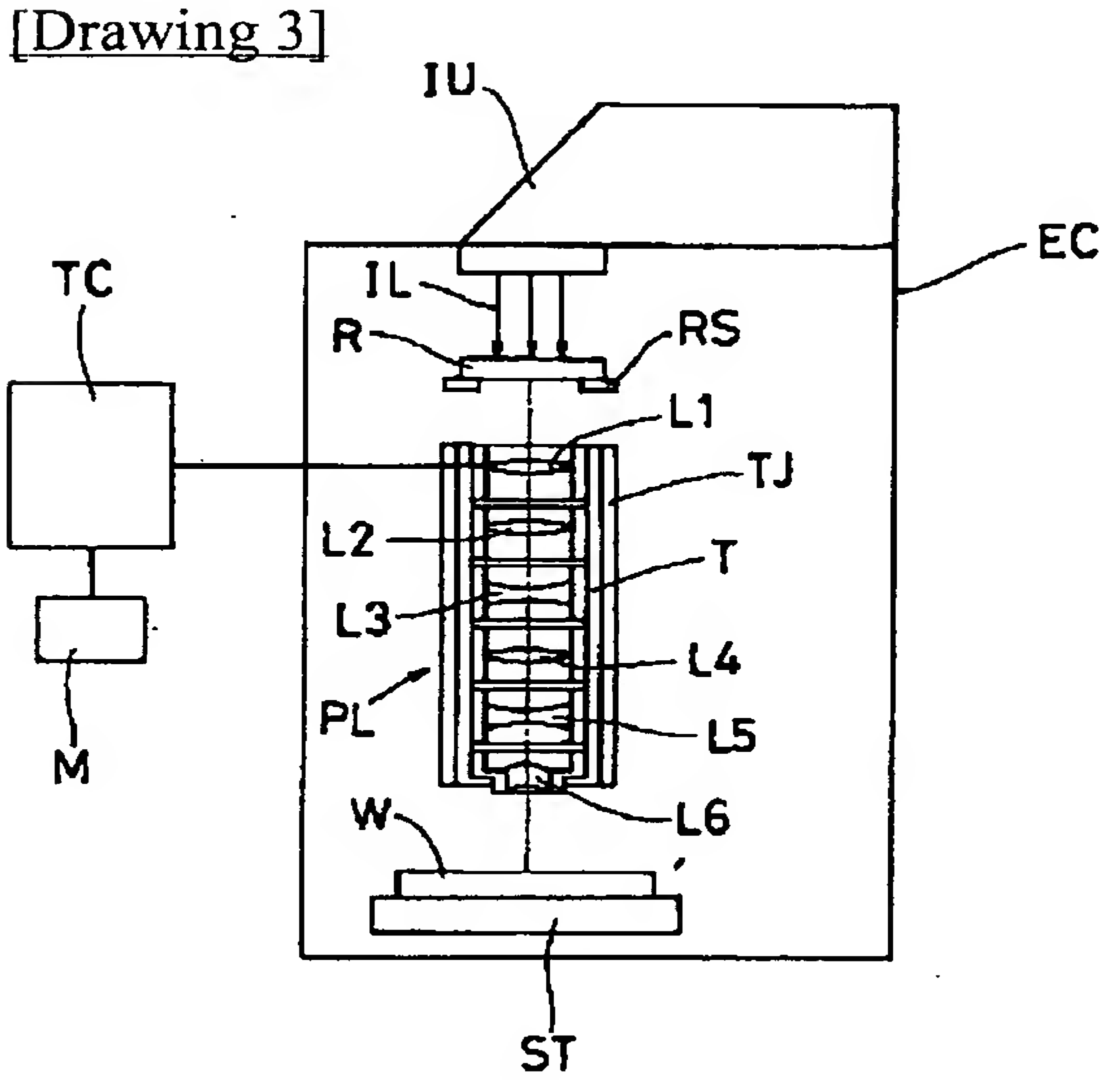
[Drawing 1]



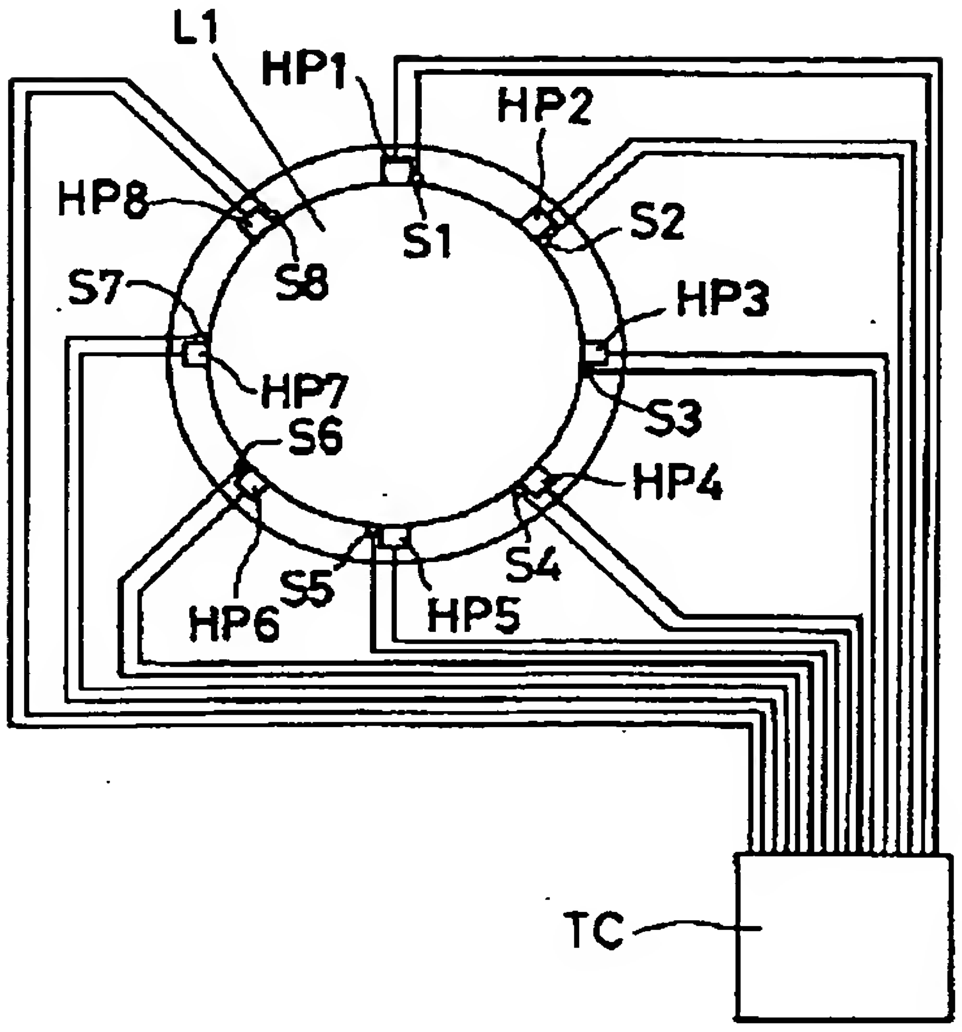
[Drawing 2]



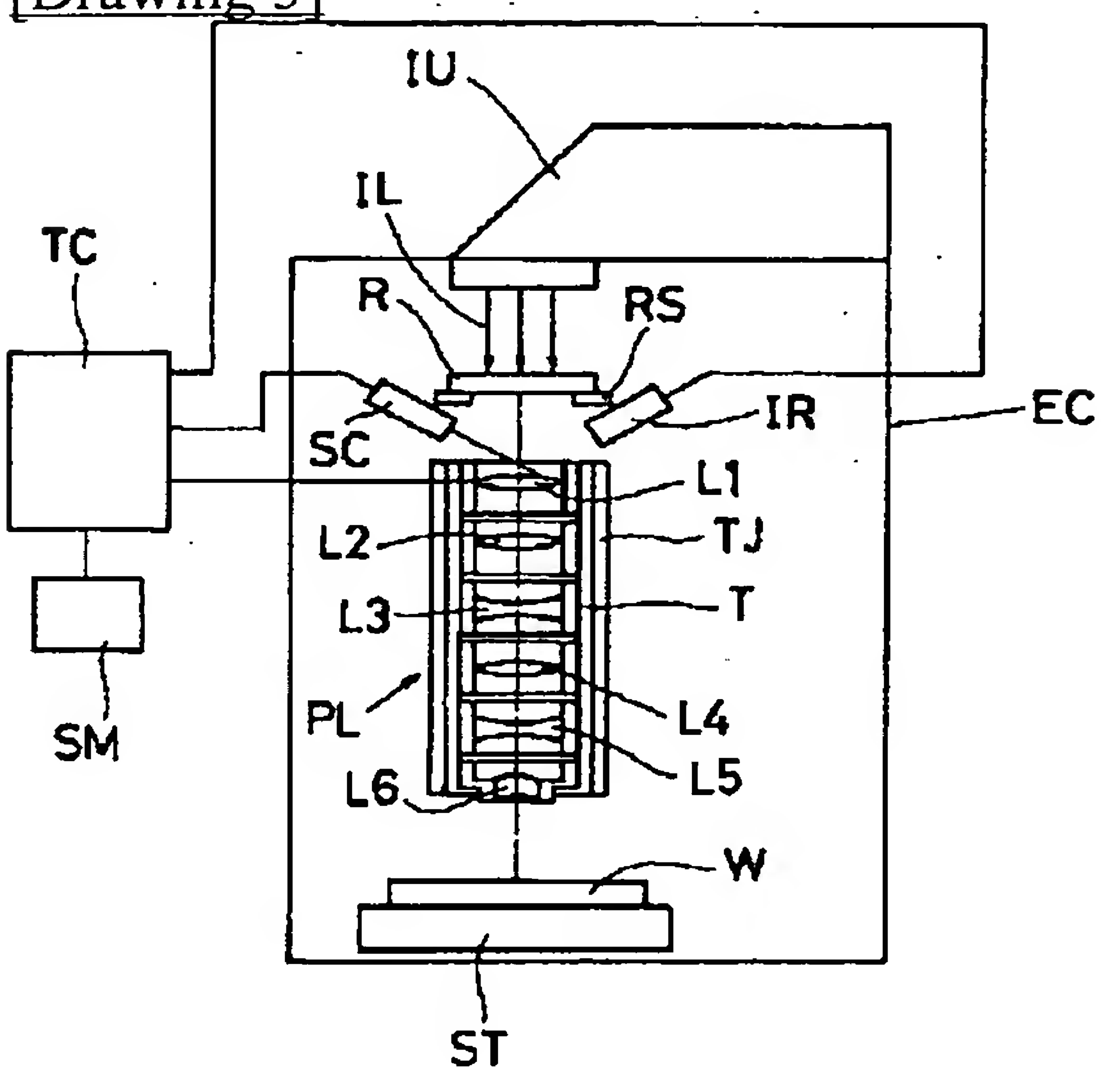
[Drawing 3]



[Drawing 4]



[Drawing 5]



[Translation done.]

CORRECTION OR AMENDMENT

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G03F   7/20    521
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H01L  21/30    516 E
G03F   7/20    521
H01L  21/30    516 A
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[Procedure amendment]
[Filing Date] May 21, Heisei 15 (2003. 5.21)
[Procedure amendment 1]
[Document to be Amended] Description
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[Proposed Amendment]
[Claim(s)]
[Claim 1] In a projection aligner including the illumination system which illuminates reticle, the substrate stage holding a sensitization substrate, and the projection optical system which forms the pattern image of said reticle on said sensitization substrate,
The projection aligner characterized by having a temperature adjustable means to change the temperature of the optical element which constitutes said projection optical system, a thermometry means to measure the temperature distribution of said optical element, and the temperature-distribution control means that amends the aberration of said projection optical system by controlling said temperature adjustable means based on the temperature distribution measured by said thermometry means, and giving predetermined temperature distribution to said optical element.
[Claim 2] The projection aligner according to claim 1 characterized by having two or more heat pump arranged in the periphery of one or more optical elements which constitute said projection optical system as said temperature adjustable means.
[Claim 3] The projection aligner according to claim 1 or 2 characterized by equipping said optical element with an infrared exposure means to irradiate infrared radiation by the desired pattern, as said temperature adjustable means, and having a radiation thermometer as said thermometry means.
[Claim 4] The projection aligner according to claim 1 characterized by having the storage means which the temperature distribution of said optical element and the optical property of said projection optical system were made to correspond, and was memorized.

[Claim 5] It is the projection aligner according to claim 1 which is equipped with a simulation means to simulate the image formation property of said projection optical system as a control result of said temperature adjustable means by said temperature-distribution control means, and is characterized by said temperature-distribution control means controlling said temperature adjustable means based on the result of the simulation by said simulation means.
[Claim 6] The aligner according to claim 1 characterized by having an infrared exposure means to irradiate infrared radiation by the pattern of the request to said optical element as said temperature adjustable means.
[Claim 7] In a projection aligner including the illumination system which illuminates reticle, the substrate stage holding a sensitization substrate, and the projection optical system which forms the pattern image of said reticle on said sensitization substrate,
The projection aligner characterized by having the temperature adjustable means which equipped said optical element with an infrared exposure means to irradiate infrared radiation by the desired pattern, and the temperature-distribution control means which amends the aberration of said projection optical system by controlling said temperature adjustable means and giving predetermined temperature distribution to said optical element in order to change the temperature of the optical element which constitutes said projection optical system.
[Procedure amendment 2]
[Document to be Amended] Description
[Item(s) to be Amended] 0010
[Method of Amendment] Modification
[Proposed Amendment]
[0010] Namely, this invention is set to a projection aligner including the illumination system (IU) which illuminates reticle, and the projection optical system (PL) which forms the substrate stage (ST) holding a sensitization substrate (W), and the pattern image of reticle (R) on a sensitization substrate. A temperature adjustable means to change the temperature of the optical element (L1 - L6) which constitutes a projection optical system (PL) (H1, H2, HP1- HP8, SC), A thermometry means to measure the temperature distribution of an optical element (S1- S8, IR), It is characterized by having the temperature-distribution control means (TC) which amends the aberration of a projection optical system by controlling a temperature adjustable means based on the temperature distribution measured by the thermometry means, and giving predetermined temperature distribution to an optical element. Moreover, this invention is set to a projection aligner including the illumination system (IU) which illuminates reticle, and the projection optical system (PL) which forms the substrate stage (ST) holding a sensitization substrate (W), and the pattern image of reticle (R) on said sensitization substrate. In order to change the temperature of the optical element (L1 - L6) which constitutes a projection optical system (PL) An infrared exposure means to irradiate infrared radiation by the pattern of the request to an optical element (L1 - L6) (SC), It is characterized by having the temperature-distribution control means (TC) which amends the aberration of a projection optical system (PL) by controlling an infrared exposure means (SC) and giving predetermined temperature distribution to an optical element (L1 - L6).

[Translation done.]